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PILOT INTERMINISTERIAL OPERATION FOR REMOTE SENSING

J. M. de Lamare, M. Bied-Charreton, A. Couzy,
A. Jahan, J. Leddet, J. Pasquet

Translation of "L'Operation pilot interministerielle
de teledetection," Paris, 25 pp., 1978?

(NASA-TM-75609) PILOT INTERMINISTERIAL
OPERATION FOR REMOTE SENSING (National
Aeronautics and Space Administration) 43 p
HC A03/MF A01 CSCL 05B

N79-20456

Unclas
G3/43 17107



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 MARCH 1979

STANDARD TITLE PAGE

1. Report No. NASA TM-75609	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle PILOT INTERMINISTERIAL OPERATION FOR REMOTE SENSING		5. Report Date March 1979	
		6. Performing Organization Code	
7. Author(s) J. M. de Lamare, M. Bied-Charreton, A. Couzy, A. Jahan, J. Leddet, J. Pasquet		8. Performing Organization Report No.	
		10. Work Unit No.	
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No. NASW-3199	
		13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration, Washington, D.C. 20546		14. Sponsoring Agency Code	
15. Supplementary Notes Translation of "L'Operation pilot inter-ministerielle de teledetection," Paris, 25 pp., 1978?			
16. Abstract Advantages and disadvantages of traditional methods of obtaining required information for land and resource management and the possibilities of remote sensing are discussed. The services available, organization and objectives of the pilot operation are presented. Emphasis is placed on multidisciplinary dialog among designers, builders, operators, interpreters and users in all phases. The principles, operation and practical applications of remote sensing systems and processing systems under the pilot operation are presented.			
17. Key Words (Selected by Author(s))		18. Distribution Statement Unclassified-Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 44	22. Price

Annotation

This pamphlet, which presents PIORS [Pilot Interministerial Operation for Remote Sensing] is most particularly intended for potential users of remote sensing:

Those already members of the Pilot Interministerial Operation for Remote Sensing;

All public and private persons who exercise responsibilities in management of national lands and its resources.

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J. M. de Lamare, M. Bied-Charreton, A. Couzy,
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INTRODUCTION

More and More Reliable and Numerous Data for Better Management of the Heritage

Management of the homeland of France and its resources raises, for various persons responsible, whatever their level, national, regional, state or even municipal, more and more complicated problems.

It concerns:

distribution, at the national level, of financial aid to areas struck by a natural disaster (drought, freezing, floods, etc.);

taking the necessary measures for preservation of the water resources of the country;

determining a reasonable policy of forest exploitation;

deciding on the best localization of large industrial installations or the best route for some transportation sub-structures . . .

Reliable data must be available to them, often quickly, in order to make the most appropriate decisions at an advantageous time.

For the examples cited above, this information is, among other things:

very accurate evaluation of damage, region by region;

a detailed "map" of the water resources of France and of their state of pollution;

a complete forest inventory, by species and area;

accurate knowledge of various environmental parameters susceptible of being affected by these substructures or of influencing the operation of these installations (localization of resources or required raw materials).

* Numbers in the margin indicate pagination in the foreign text.

These New Needs for Information Risk Eventually Inability to be Satisfied by Traditional Systems

Means presently are used, which permit these data to be obtained. These are conventional information systems, including:

the use of administrative and statistical files (survey, industrial and commercial establishment files, etc.);

data acquired by periodic censuses carried out by INSEE¹ and a certain number of ministries which furnish data on population, housing, agriculture, etc;

sample surveys, such as the annual land use survey of the Ministry of Agriculture;

other sources of information, like that supplied by water, air, soil pollution measurement systems . . .

Some of these systems presently are satisfactory.

This is the case, in particular, of the sample surveys, which provide abundant, detailed and numerous data, permitting direct contact with the phenomenon observed.

Nevertheless, they have a number of shortcomings, including:

Slowness: it is an obstacle to obtaining exhaustive results by census.

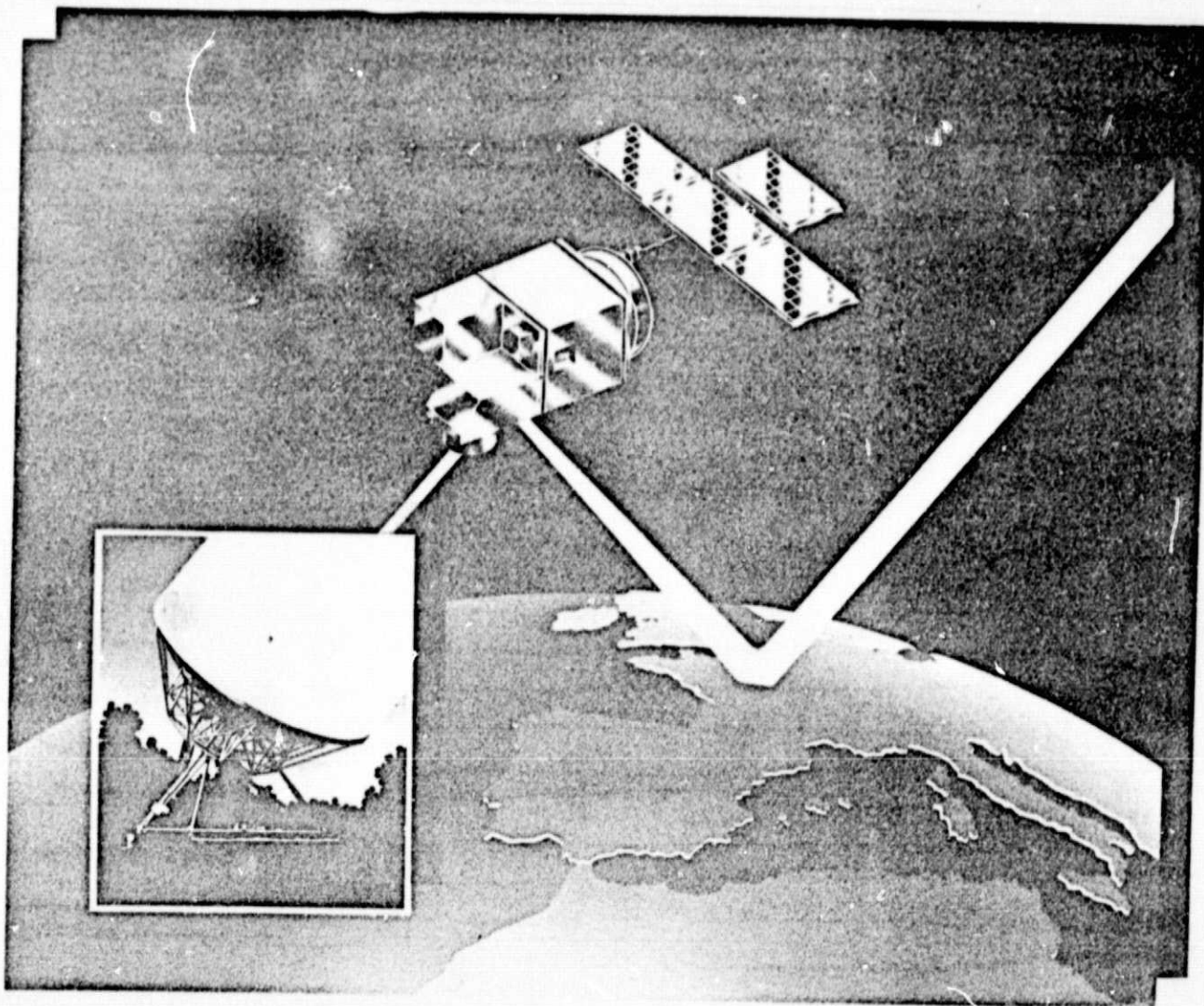
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For example, to make a forest inventory with ground based means undoubtedly provides abundant information which is indispensable to good management.

However, with the available means taken into account, it is only possible, for example, to accomplish this inventory on 5 to 10% of the zones of interest per year. Therefore, there will only be useful data every 10 or 20 years.

The time for cutting one hectare of forest can be compared with these substantial periods. It is about 12 days.

¹ [INSEE - National Institute of Statistics and Economic Studies]



The difficulty of quickly having a precise picture of a situation at the time when it is needed, on all or a major part of the area.

The difficulties found in following the evolution of the phenomenon observed.

The time required to carry out investigations and their cost makes their republication impossible at a sufficient frequency to constantly measure perceptible variations.

Most often, only obsolete sets of data, time shifted with respect to each other, can be available.

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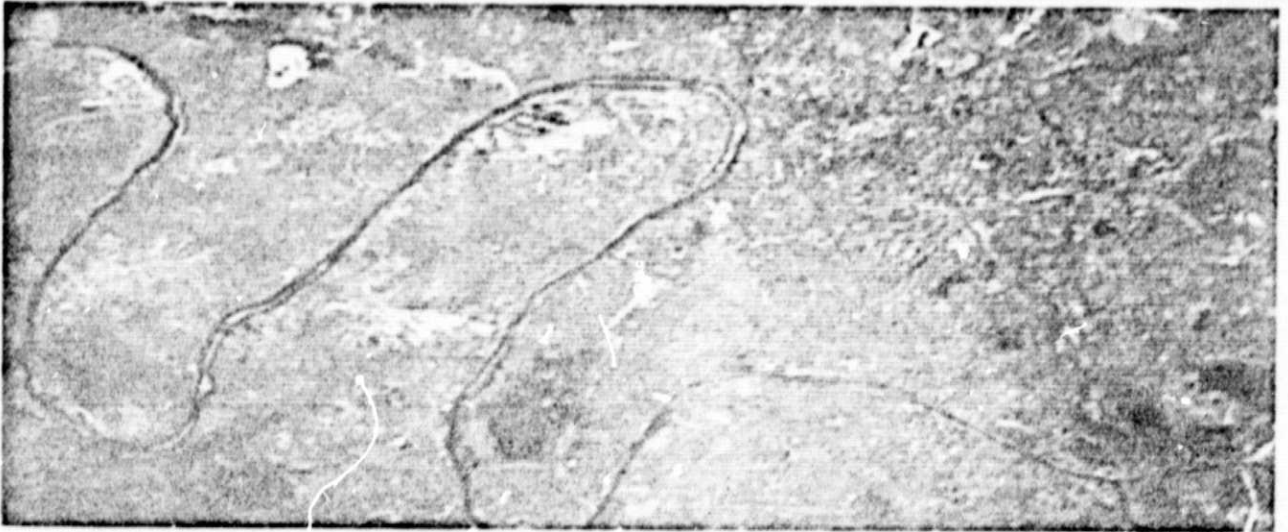
There is a New and Original Solution to These Problems of
Obtaining Information: "Remote Sensing"

Its principle is simple. Instead of obtaining data directly /5
by ground survey, as is the case of the traditional information
systems, they are obtained indirectly by means of remote physical
measurements aboard an aircraft or a satellite. These measure-
ments deliver the amount of light emitted or reflected by the soil
in different wavelength bands.



Paris region: Landsat image no. 215-26, 21 November 1975. Color composite
obtained on screen without rectification, by superimposing channels 4, 5 and
7, in the yellow, magenta and cyan, respectively. Factory smoke plumes and
their diffusion in space are very clearly distinguished.

Compared to information received by the classical methods
"on the ground," remotely sensed information has a certain
number of particularly interesting characteristics, including:
the homogenous and exhaustive nature of the observations;
repetitivity, i.e., the possibility of periodically ob-
taining the same data on the area observed at short intervals,
so as to follow the evolution;
the abundance of the data received and its synthetic nature;
the possibilities of rapid processing offered by the data
processing system.



The same scene, but taken 13 April 1976. The atmospheric pollution is much less.

On the other hand, it cannot be hidden that this technique also has difficulties. The main one is that the information received is not directly that which is sought and that, to obtain the latter, the physical measurements must be correctly processed and interpreted. This requires perfection of the methodologies adopted.

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This relatively new technique is constantly progressing, because of the active research which is being conducted in this field, by the industrialized nations in particular. In some cases, it has passed the experimental stage to become preoperational.

Thus, in the United States, remote sensing has found applications in the analysis, sometimes as a complement to other means, of several major subjects of interest to management of the land and of its resources.

Among them, the following can be cited :

- geological and mining research;
- water resources inventory;
- crop predictions;
- land use study.



Study of land use in Loire valley: Chinon-Bourgueil (Indre-et-Loire) region.

The color composite permits discrimination of the rivers (in black), deciduous forests in bright green to dark green, according to population density and age, coniferous in dark green-black, the meadows of Vienne and Authion in pale green,



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corn also in green in the grain areas which appear yellow to orange, as well as the Bourgueillois vineyard. The geomorphological and agricultural units show up well in this area of small plots.

It was Imperative that the Managers of the Land of France Quickly Profit by it.

For France, some applications will be more difficult, because of the greater heterogeneity of the landscape. For good observation, this requires higher resolution equipment than that now used in the USA.

However, such equipment will be available in the near future (beginning of the next decade). Therefore, it is not too soon to begin to prepare for its use. /7

An important task should be performed, to test and adapt existing techniques or those being developed, to the needs of future users and to familiarize them with them.

This is Why the Pilot Interministerial Operation for Remote Sensing (PIORS) was Established in 1976

PIORS is the offspring of four of the principal services responsible for management of the land and natural resources:

Ministry of Agriculture;

Ministry of Culture and the Environment;

The Ministry of Equipment;

The Land Management and Regional Action Administration (DATAR).

The General Administration of Scientific and Technical Research (DGRST) has joined it, because of its general mission of the encouragement of the development of new techniques.

These administrations have entrusted to PIORS the mission of preparation, for their review, of the use of this technique, with the support of various organizations in France which are competent in research and development.



Study of land use in Loire valley: Chinon-Bourgueil (Indre-et-Loire) region.

Uncontrolled classification based on analysis of principal components of the same area brings out 17 classes: water (dark green and light green); conifers (pale green); broad leaved trees of various ages (blue, pale yellow, pale ocher); vineyards and crops on sandy soils in small lots (maroon);



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5 classes of meadows, according to soil and type of grove (ocher, purple, dark blue, blue grey, pink); 4 categories of grain and multiple crops (yellow, orange, ocher, ocher pink); cities in dark yellow.

1. SERVICES PIORS WISHES TO PROVIDE FOR YOU

Definitions of the directions to be given to methodological research and development in the field of remote sensing presupposes a comparison between the "state of the art" and user needs, those of the member administrations of PIORS in particular. /8

Within the framework of such an application, the services which PIORS wishes to provide to potential users of remote detection are at 2 levels.

that of the assistance which can be given them in the end in their activity to resolve the problems they encounter, the solutions of which depend on remote sensing techniques;

that of a method of operation which permits the setting up of a system which meets their specific needs.

1.1 Within the Framework of Your Activity

These services consist of the following.

Information on "the State of the Art" in the Remote Sensing Field

PIORS has attempted to point out the research and applications to which remote detection has given rise up to the present:

on the one hand, by systematically examining the specialized literature, mainly from American sources;

on the other hand, by conducting experiments in parallel, which permit verification of their conclusions and feasibility.

As a matter of fact, remote sensing being an experimental science, there can be no question of generalizing the results obtained on other continents, under different relief, climate and area conditions, to the homeland and its specific nature, without preliminary experiment.

This information will be disseminated to technicians and scientific personnel capable of constructive criticism of it, /9



Vosges: Landsat image 211-26, 28 August 1975; the color composition brings out the large forested blocks and the major population types (broad leaved trees, conifers) and demonstrates the possibility of making a forest inventory by numerical processing.

above all to responsible persons of the member administrations of FIORES. The latter will then be able to give information on their responses and to formulate their needs.

Assistance in the Expression of Needs

During experiments conducted in various fields (agriculture, habitat, hydrology, etc.), working sessions will be set up between the services of different ministries concerned, subject matter specialists and remote sensing technicians.

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During these contacts, future users may formulate their needs in a more and more precise manner.

Acquisition of a Remote Sensing Base

This flows directly from the dialog which future users have with the remote sensing specialists.

They will acquire the required knowledge of the techniques used in remote sensing and of the possibilities and limits of this means and its field of application.

In parallel, remote sensing specialists will become familiar with actual practices of land management used by the responsible persons of various ministries.

This exchange of knowledge between future users and remote sensing specialists will permit the creation of a common language, which will assist in the expression of needs and improve the responses to them.

Improvement of an Adapted Tool

At the end of the experimental phase, PIORS will have available:

- a global inventory of the principal needs of those responsible for land management;

- evaluation of the usefulness of remote sensing data in the satisfaction of these needs.

These needs will be very different, according to the categories of the requestors, land managers or scientific users, according to the nature of the problems dealt with.

PIORS has the task, with the evaluation made by the users taken into account, of determining, with remote sensing technicians, the tool which permits the maximum useful information to be obtained at the best cost.

1.2 In Perfection of a Method of Operation

The method of operation perfected by PTORS to deal with this problem has the following characteristics:

- it associates, in multidisciplinary groups, all persons directly concerned with remote sensing in France (future users, equipment makers, processing technicians, investigators);

- it sets up a dialog between these different "user groups," to obtain as large as possible an exchange of views and of objective elements, to set up the inventory of needs;

- it takes into account what has already been accomplished in France and abroad in the field of remote sensing, to generate hypotheses of application at the national level;

- among these hypotheses, it only considers established those which have been the object of an experiment which permits validation of results;

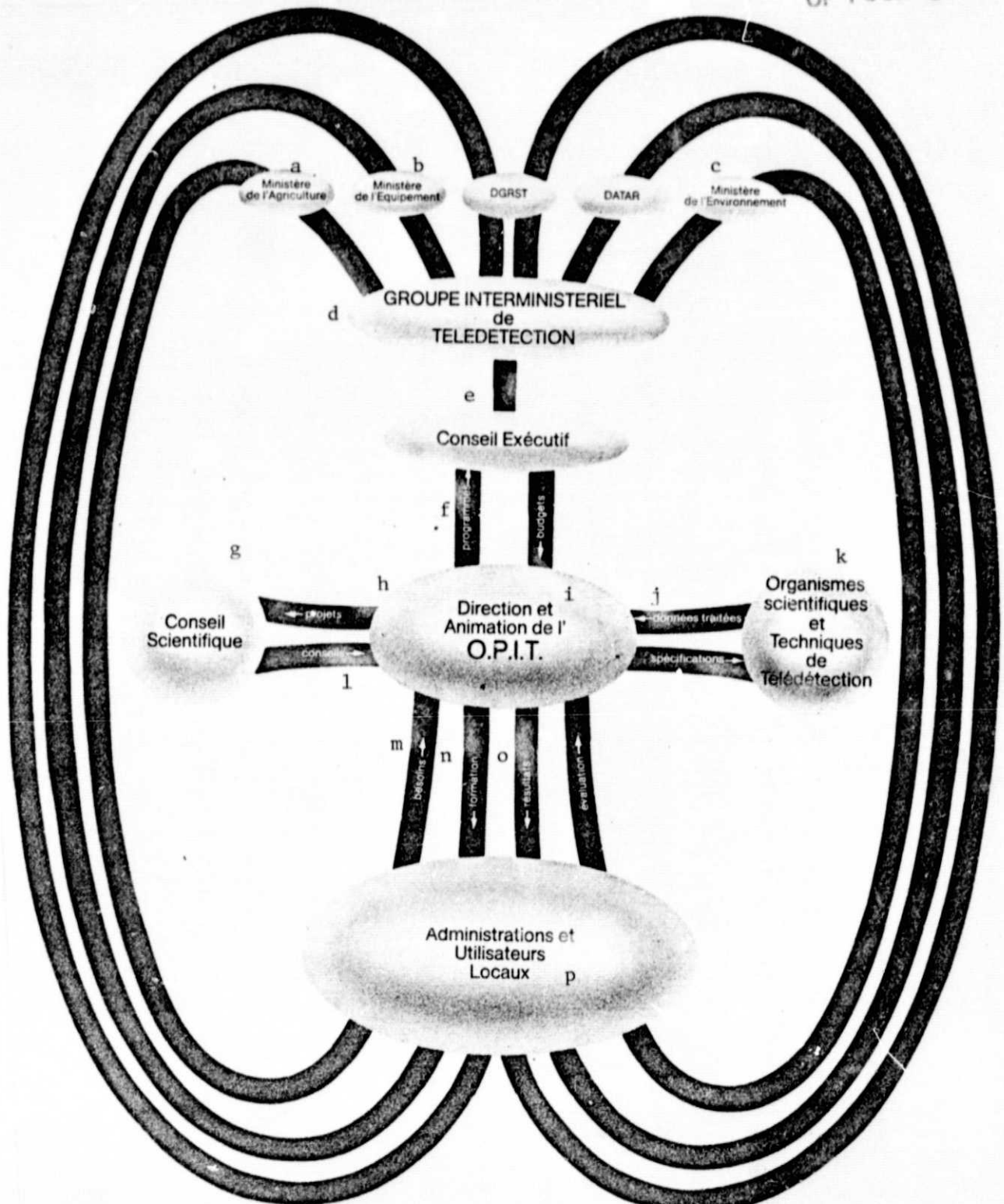
- it only retains as solutions, those which, tested under the most varied conditions, have produced results which permit generalization.

This very progressive and pragmatic method of operation offers the maximum guarantee to users that:

- decisions only are made with complete knowledge of the cause, after having verified the expected results;

- the users themselves design the configuration of the most suitable tool to satisfy them;

- the greatest conformity between the value of the service rendered (useful remote sensing information) and its cost price is one of the threads of this research.



- | | | |
|--------------------------------|------------------------|-----------------------------------|
| Key: a Ministry of Agriculture | e executive council | k scientific organizations and |
| b Ministry of Equipment | f programmes | remote sensing techniques |
| c Ministry of the | g scientific council | l advice |
| Environment | h projects | m needs |
| d Interministerial group | i POIRS management and | n formation |
| for remote sensing | executive | o results |
| | j processed data | p local administrations and users |

2. PIORS: SPECIFIC STRUCTURE IN SERVICE TO USERS

2.1 What is PIORS?

Above all, the five ministries and administrations which make up a "community of interest," are to conceive and develop a remote sensing system project, which very accurately meets the needs of future users.

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Reorganized in 1976 into an interministerial structure, they are :

Ministry of Agriculture;
Ministry of Culture and Environment;
Ministry of Equipment;
Administration of Land Management and Regional Action (DATAR);
the Administration of Scientific and Technical Research (DGRST).

2.2 Who Makes up PIORS?

PIORS is made up of :

The Interministerial Group for Remote Sensing (GIT)

the five ministries and administrations concerned first formed the "Interministerial Group for Remote Sensing" (GIT), to which each Minister has designated a representative;

GIT plays the part of the "Administrative Council" of the "Pilot Interministerial Operation for Remote Sensing"; it determines broad PIORS policy, names its Director and decides its budgets;

Executive Council

An executive council of five members, each belonging to one of the administrations of which PIORS is made up, has received authority from the Interministerial Group for Remote Sensing to make certain decisions (contracts to be approved, control of budget execution, etc.); among other missions, it has that of facilitating, when necessary, contact and liaison between the various services of the ministries and PIORS;

Director of PIORS

This person, named by the Interministerial Group for Remote Sensing and responsible to it alone, ensures the execution of various actions set down in the program; for this, he has available :

An Operations Staff

It is made up of 12 persons working part time, who are officials and scientists belonging to the various administrations, who have been made available temporarily to PIORS;

The director and members of the operations staff of PIORS :
prepare the programs and budgets of various activities and experiments provided for in the general program;

constitute and put into operation the various multidisciplinary groups required to successfully conduct various experiments;

conduct or participate in the conduct of other activities provided for in the program (forming and informing future users, evaluation of experiments, research, etc.);

A Scientific Council

Among other things, PIORS benefits from the counsel and advice of a number of high level persons from the scientific world, who have agreed to make available their competence to it, within the framework of a "Scientific Council";

Financial Means

Its annual budget, on the order of 5 million francs, permits it to contract some research and study operations to competent organizations.

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Thus, PIORS is an original structure, the characteristics of which can be summarized as follows.

It is :

Specific; it unites users and technicians to solve a precise problem, the evaluation and transfer of an advanced technology, remote sensing;

Open; future users, whether they belong to the public or private sectors, are equally concerned;

Evolutional; its internal organization is flexible and permits it to adapt to the various technical problems encountered;

Temporary; it is required to disappear, when a solution to the problem set before it has been found.

2.3 What are Its Objectives?

The mission of PIORS is to conduct a program of activities, which can permit operational and efficient use of remote sensing in the 1980's by its member administrations and, in a broader way, by all users.

To accomplish this mission, PIORS has established three objectives.

A. To Inform Potential Users of the Possibilities Offered by Remote Sensing

Based on a very extensive analysis of the systems used in both France and abroad, of experiments conducted and of results obtained, a first inventory of the "state of the art" has been established.

In parallel with this step, experiments have been conducted, to validate these results and to test their feasibility in the specific context of France.

These feasibility studies are not limited to existing systems, but are equally interested in the generation under study or implementation, the operation of which is foreseen in the 1980's.

This information will be brought to the attention of users in fields likely to be interested in it.

B. To Inventory User Needs

It is a question of obtaining, from various potential users, /13
a very clear expression of their information needs, in particular :



Study of forest fires in Mediterranean region:

1. Landsat image of 19 September 1976; color composite of channels 4, 5 and 7 after rectification; gorges of the Gard, city of Nimes and its suburbs and railway station are distinguished perfectly; forest masses stand out very precisely in blood red and wastelands, as well as the steep sides of the gorges, in orange; cultivated areas are bright orange or white (vineyards); fires are very sharply defined in black or gray-blue; 4 major fires (several hundred hectares) and a half-dozen fires of a few tens of hectares are seen.

The nature of the information they desire to obtain (for example, extension of suburban zones, water quality, land use, etc.);

Their frequency (for example, every three years, every fifteen days, etc.);

The presentation requested (maps, graphs, statistical tables, etc.);

The desired period for availability (a few hours, one week, one month, etc.);

The required precision (area within 5%, distances within 20 meters, etc.).

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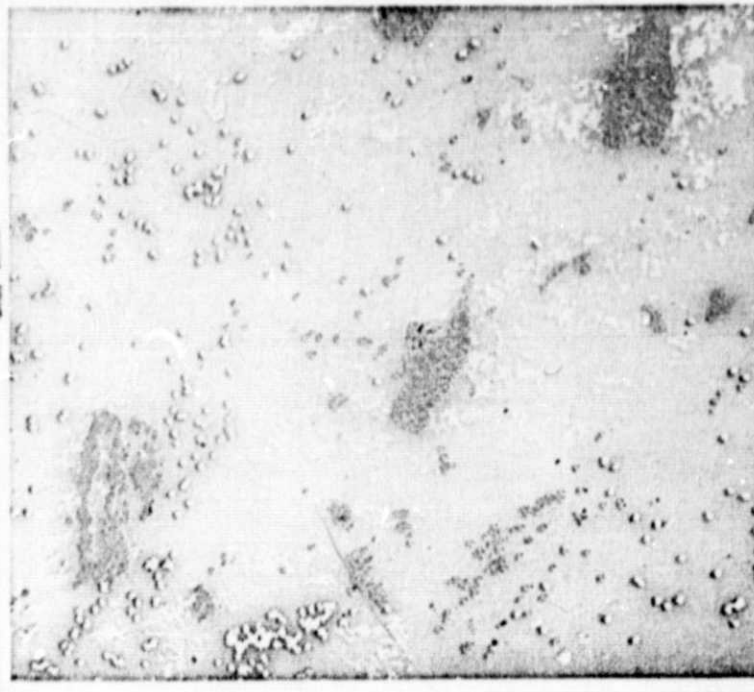
Study of forest fires in Mediterranean region:

2. Result of controlled classification of this portion of image by hypercube method, showing the 4 major fires in orange and one class of fires in red (this mixes the fires and the gorges of the Gard); forests grouped in one class in green (Aleppo pine, evergreen oak), city of Nimes, vineyards and bare soil cultivated plots in very bright yellow, St. Cezaire industrial district and vineyards in blue.

C. To Calculate the Bases of a Remote Sensing System Which Permit Satisfaction of Future User Needs at Best Cost

It attempts to direct and encourage the research, the means and the technical competence available to the country, while leading users to obtain a greater benefit from the original possibilities of remote sensing.

Likewise, it will take into account the interests of the policy of cooperation, which France intends to carry out internationally in the field of remote sensing.



Study of forest fires in Mediterranean region;

3. Result of same classification, with point image arrangement taken into account, permitting elimination, in particular, of the gorges of the Gard from the "fire" class in red in photograph No. 2; all fires occurring in 1976 are brought out and the area destroyed is measured automatically.

2.4 How Does it Plan to Accomplish Them, What Are Its Projects, Its Program

In part, it is through experimental projects which it is conducting, that PIORS intends to attain the objectives it has set. The main effect is to have available a global base of experimental results for the development of its program.

The aim of the experimental projects which PIORS foresees is :

To test the feasibility of present and future processing systems and methods;

To evaluate the respective results;

To optimize performance.

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The optimization will consist of determining the specifications of the type of material most suited to detect the

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phenomena it desires to observe, and to perfect the most efficient methods and treatments for providing the desired results.

Each experimental project will evolve in six stages.

Project Conception

That is to say, the choice of targets of application and areas of experiment with the users. Thus, in this stage, the first two objectives will be attained, "user information on the possibilities offered by remote sensing" and "census of user needs."

Acquisition of Remote Sensing Data

That is to say, the recording of radiometric data provided by remote detection of the observation zone.

Collection of Terrain Data

It consists of collection of a certain number of elements observed directly on the ground in the zone selected.

This study, which always is carried out in close collaboration with the users, can be conducted either :

by retrospective inquiry of the competent services; or simultaneously with the acquisition of remote sensing data.

In the latter case, the operations "acquisition of remote sensing data" and "collection of terrain data" proceed at the same time and can be combined.

Processing of Remote Sensing Data

That is to say, the application of appropriate processing to the data recorded by remote sensing, in order to transform the results.

Comparison of Results Obtained by Remote Sensing with "Ground Truth"

The distribution of the variations between the information collected on the ground and the results obtained after treatment of the sensing data will be determined.

Evaluation of Results and Processing Methods

During this stage, the users will learn the adequacy of the information provided by remote sensing to the needs they have expressed, as well as the performance of the processing methods used.

In principle, this evaluation should be exhaustive, i.e., it should concern :

- all the treatments available;
- all the subjects on all the varieties of site.

This evaluation will be carried in teams which combine users, technicians and PIORS members.

During this stage, PIORS will acquire the required elements to achieve its third objective : "to calculate the bases of a remote sensing system which permits satisfaction of future user needs at best cost."

In fact, after having balanced these experimental differences, PIORS will be in a position to determine the general appearance of a remote sensing system which will be most capable of suiting future users.

Of course, the components of such a system will be sufficiently diverse to respond to the multiplicity of problems raised.

3. REMOTE SENSING: A MODERN TECHNIQUE FULL OF PROMISE

3.1 What are the Practical Applications of Remote Sensing

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This means has a great variety of possibilities. To give the best account of it, it is sufficient to list some current uses in the United States and other countries :

- determination of the best locations for oil well drilling; to bring out previously unknown faults before building dams (France);

- identification of waste materials and effluents polluting the sea;

- inventory of forested areas and following their development (North America);

- measurement of seeded areas and application to estimation of crops.

3.2 What is its Principle?

Remote sensing can be defined as :

"a set of techniques used in aircraft, balloons and satellites, for the purpose of studying either the Earth or other planets or the atmosphere, by using the properties of electromagnetic waves emitted, reflected or diffracted by the various bodies observed."

We shall only deal here with the study of Earth resources.

A very simple example permits the best comprehension of the principle. It is the mechanism of our own vision, which performs by the same process as that of remote sensing.

When we look at an object, its shape, color and brilliance are as much information as is transmitted to us through the light reflected by this object.

"We pick up" this information by means of our eyes, which send it to our brain, where it is immediately "processed", as a function of the models which we ourselves have. This permits us to interpret it.

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The human remote sensing system, however perfect it is, has limits, thus :

1. we cannot see objects too far away or too small;
2. we do not pick up the electromagnetic waves which make up the light reflected by the object which we see, except within a limited zone, that of the visible radiation;
3. we cannot "memorize" everything we see;
4. it is impossible for us to exactly quantify what we observe; at the very most, we can estimate distance, area and volume, by means of our reference system, with the risk of large error.

Remote sensing by aircraft or satellite makes available much more high quality material, and its possibilities are greater in some respects :

1. it can pick up information at a very great distance;
2. it uses the entire range of the electromagnetic spectrum and not only the band which corresponds to visible radiation;
3. it records everything it sees, places it in memory and reproduces it accurately;
4. it receives, in addition to essentially qualitative data, as is the case of the eye, quantitative data; thus, it is capable of measuring the relative intensities of radiation of various wavelengths reflected by a single point.

Such information is very interesting, since it makes it possible to examine the nature and state of the soil and vegetation which it finds.

Besides, some remotely sensed radiation has particular properties. This is the case of the near infrared radiation bands. They are very strongly reflected by chlorophyll. Because of this, they can be used to identify different species of plants and evaluate their vigor.

Applications in the establishment of agricultural statistics /16
can be hoped for (the nature of crops, detection of plant diseases, parasites, etc.). This is only one example among others.

3.3 How Does a Remote Sensing Chain Operate?

To be able to operate, a remote sensing chain has to combine three elements :

1. a sensor, the equipment which permits recording of electromagnetic radiation from the sun in a certain wavelength range;

the best known sensor is the camera, which provides an image on film of a scene observed at a given time, by picking up the electromagnetic radiation which corresponds to the visible frequencies;

among the modern sensors used, which operate at other wavelengths than that of the spectrum, the following can be mentioned :

radiometers, which permit recording of radiation, by generally dividing it into different spectral bands within an extended wavelength range;

radars, active systems which record "the echo" of the electromagnetic radiation they emit; the interest in them is their ability to be used at all times for, at the frequencies they use, the waves have the property of not being stopped by clouds;

2. a vector, which is the observation vehicle or "platform," which permits the sensor to be transported to high altitudes;

the vectors can be aircraft, balloons or satellites;

the measurements recorded are either :

transmitted in real time to a receiving station, or

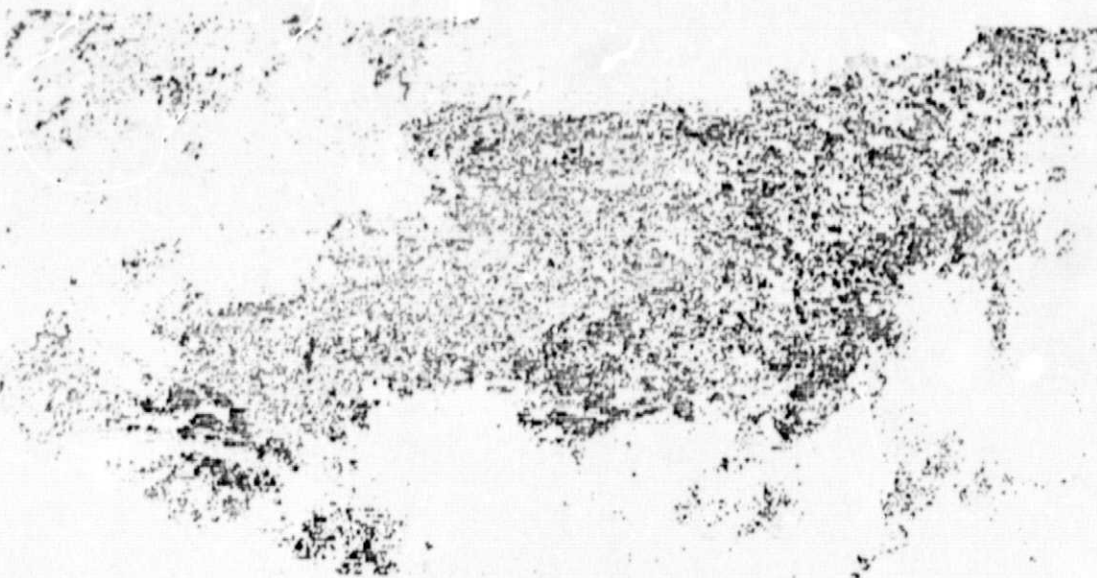
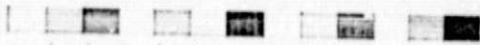
stored for later transmission (at the time of landing for an aircraft or of passage within sight of a receiving station for a satellite);

3. a set of means of ensuring the transformation of the physical measurements received by the sensor into useful information;

these means consist of calculators, processing programs and display and data or result reproducing devices.

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Properly speaking, remote sensing consists of four chronological phases.



Visualization on tracing table of results of controlled processing of Landsat scene 211-26 of 13 August 1976 (Vosges, Forest of Haguenau, Lower Rhine); the 13 color classes correspond to different species of trees; broad leaved trees are green, blue, yellow; conifers, brown, red (only the forest has been classified); compare this result with the color composite of the Vosges on page 11).

Data Perception or Collection

During this phase, the electromagnetic radiation emitted or reflected by the soil is recorded by the sensor.

Preprocessing

A certain number of corrections generally are required, to make the data homogenous before processing :

geometric corrections, which remedy stability defects of the vector (roll, pitch, variations in altitude, etc.);

radiometric corrections (adjustment of differences due to illumination and atmospheric conditions associated with recording).

Processing

These preprocessed data are not directly useable as is. The purpose of processing is to transform to a form which permits interpretation, then the presentation of results corresponding to user needs.

The processing procedures are numerous and complicated. There is no question of describing them in detail here. In a general manner, two methods are used:

one consists of classifying the data by their degree of homogeneity, before study of the meaning of each of the classes thus constituted; this method is called "uncontrolled";

the other establishes an interpretation model at the start, by means of "ground truth" observation; this category of methods, called "controlled," has the characteristic of incorporating data taken on the ground in the processing programs.

The fantastic amount of data received by satellite for coverage of the territory of France, on the order of a billion for the American Landsat satellites and more than 25 billion for the future French Spot satellite, sees to it that the processing procedures use, to a great extent, data processing.

Interactive systems, which use, by means of a display screen, the possibility of deciding results at any time during treatment, permit the operator (or user) to intervene during processing. Thus, he can select, among various procedures, that which appears to him the best adapted to the problem he has to solve.

Presentation of Results

This is the specific, tangible result of processing. Various procedures are used, which permit visualization of the information, for the purpose of its utilization by users. For example, isodensity curves on a tracing table;
display on a black and white or color console;

photographic reproduction;
color charts on tracing table;
numerical table, statistics, etc.

3.4 Who in France is Involved in the Remote Sensing Process?

There are, in fact, three categories of actors who are, for various reasons, directly interested in the development of remote sensing in France. They are the following.

1. Producers

The "technicians," i.e., the organizations which produce the material required for the acquisition and use of remote sensing data, or who provide the supplies or treatment, are grouped under this title. The following are found in this category:

upstream, the instrument makers:

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sensing equipment (cameras, radiometers, radars, etc);

data processing equipment specially adapted for the processing;

then, the specialized data receiving and production organizations.

Most of the time, they have available heavy resources (aircraft-sensors-computers), and they often are organized to provide the various phases of the remote sensing operation (sensing, pre-processing, processing, display of results).

The most important among them in France is the Aerospace Remote Sensing Development Group (GDTA).

It is an economic interest group, which includes BRGM, CNES, IFP and IGN.²

Other research organizations are involved equally: ORSTOM, CNEXO and INRA.³

² Bureau of Geological and Mining Research, National Center for Space Studies, French Petroleum Institute, National Geographic Institute.

³ Office of Overseas Scientific and Technical Research, National Center for Ocean Management, National Institute of Agricultural Research.

To them, it is advisable to add a number of laboratories of the universities, the National Center of Scientific Research and of the higher schools, which play a very active part in the development of remote sensing methods.

Finally, some private companies likewise are able to provide remote sensing services.

While France has varied airborne data acquisition resources and operators, on the other hand, for the moment, "satellite data" come from American earth observation satellites, principally those of the Landsat series (Landsat 1 and 2, to which Landsat C, the launching of which is anticipated in 1978, will be added).

Thus, at present, each point of French territory is overflown every nine days, and the data are received directly by the Fucino (Italy) station. These data are distributed in France by GDTA.

Within the framework of the National Earth Observation Satellite Project, this area coverage will be supplemented in 1984 by the injection into orbit of the French Spot satellite, which will provide a considerable amount of data particularly adapted to our needs.

2. Users

They are the "future clients" of remote sensing, i.e., all the organizations, administrations and private companies which are or will be interested in the remote sensing information, by reason of the nature of their activities. They are the following in particular.

The Administrations and Their Central, Regional and Departmental Echelons

Besides the member ministries and administrations of PIORS, the following will be found in this category:

a certain number of other ministries and administrations, which are directly concerned with remote sensing applications;

this is the case of the Ministries of Cooperation, Industry, Interior, Finance, Universities and Research;

then, official organizations which, not able to be considered as direct users, nevertheless, can be involved in the remote sensing process, either as:

responsible for a field involved in its applications; in particular, this is the case of the National Institute of statistics and Economic Studies (INSEE), as the producer of national statistical information;

capable of bringing expertise to its development; for example, the Data Processing Mission⁴ of the Ministry of Industry or the Ministry of Universities.

Public Organizations and Local Groups

These could be, for example, Electric Power of France (EDF), National Office of Forests (ONF), certain regional or departmental public companies, municipalities, etc.

The Private Sector

Some private sector companies or interdisciplinary organizations, the activities of which are in the field covered by the applications of remote sensing (petroleum exploration, pollution control, maritime fisheries, pulp and paper industries, etc.), can be future users of remotely sensed information.

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In the same manner, some private owners or managers of large plots of land of the national territory (forest or agricultural management) could be, in the near future, interested in remote sensing.

This list is not exhaustive. Nevertheless, it permits the large numbers of potential users of remote sensing in France to be made clear.

⁴ Data processing is an essential element of the remote sensing process, and its developments have a favorable effect on the progress of this technique. Besides, the extension of applications of remote sensing will be conditioned by the growth of the data processing market.

3. Subject Matter Specialists

This term covers investigators capable of becoming involved downstream in the remote sensing chain, at the processing and interpretation levels.

PIORS calls on them to assist in exchange and mutual understanding between the producers, who furnish the remotely sensed information, and the users, who evaluate its quality and the degree of response to their needs, within the framework of experiments provided for.

Specialists in certain major subjects, such as study of the soils, plant growth, urban studies, cartography, pollution, etc., are capable of "modeling" the concerns of the users, in terms of the remotely sensed information.

They work in parallel with the producers, so that they take into account the multiple constraints on utilization.

3.5 What PIORS Wishes to Contribute to Various Persons Involved in the Remote Sensing Chain

One of the guiding ideas of the initiators of PIORS is to determine "efficient use" of the remote sensing tool, before it is put into use.

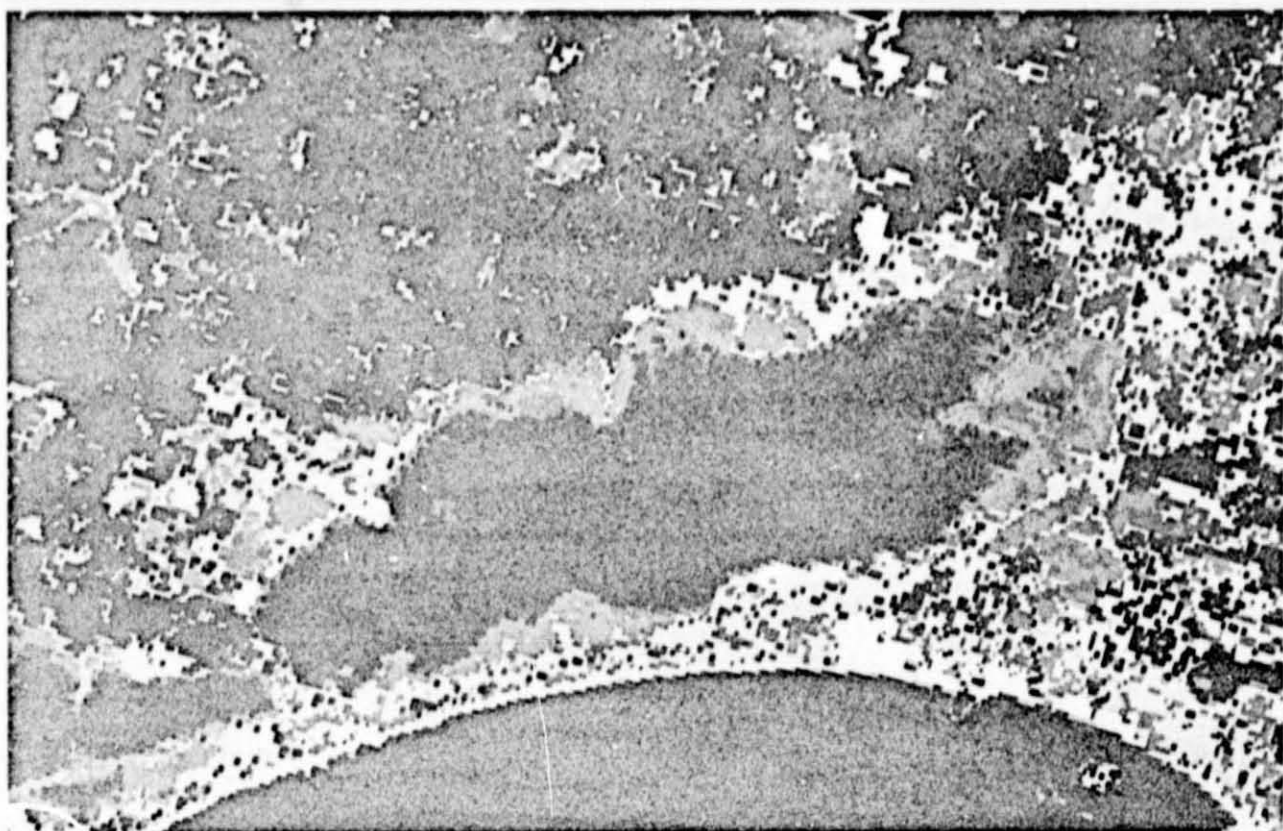
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This technique, like most advanced techniques, has the particular property that it cannot be conceived in isolation in a laboratory, then to be furnished on the market "ready to use."

The definition of an adapted remote sensing system implies not only that the users are consulted, but that they participate in its development.

This is why the solution adopted by PIORS consists of a direct responsibility and development in common of the downstream aspect of the remote sensing chain, i.e., of the operational results which are of principal interest to users.

Within this general framework, PIORS wishes the various persons involved in the remote sensing chain to be able to find:

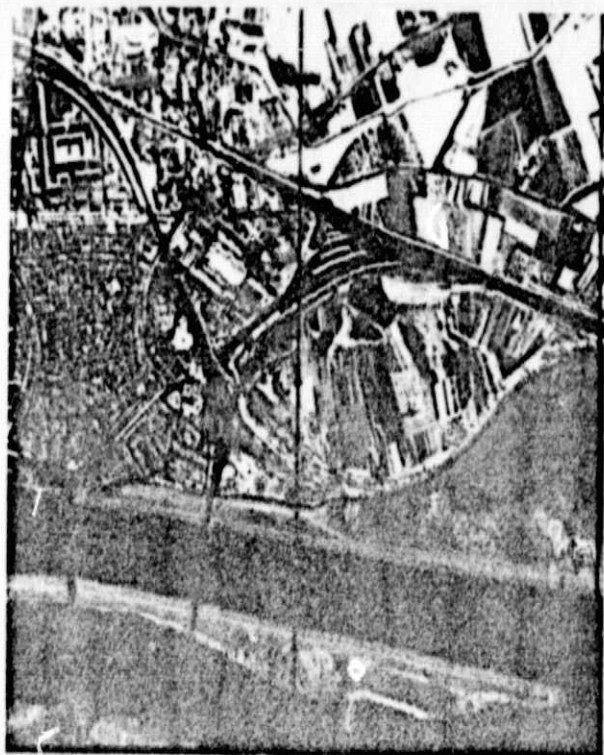
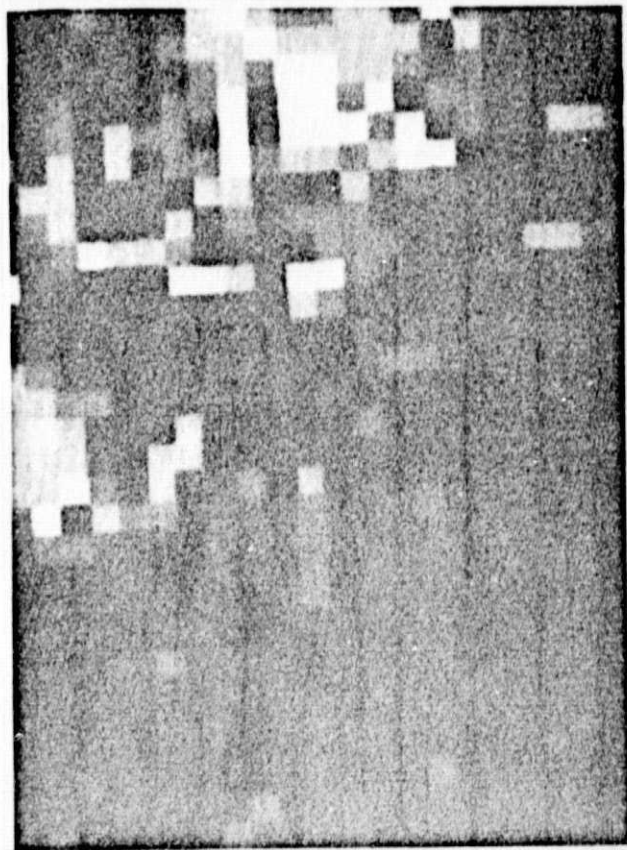


Languedoc coast: treatment of Landsat image 212-30 of 6 July 1975, directed towards study of water (discharges, turbidity, salinity . . .), wet regions and their approaches, and vegetative cover; controlled classification which provides statistical tables and cartographic representation of 24 categories, which bring out brackish water, salt water (3 classes), fresh water (3 classes), wet regions (2 classes), salt marshes, wet soils, urbanized zones (5 classes), arable land, vineyards and orchards, forests (broad leaved trees, conifers, mixed), wastelands, sand and gravel and bare terrain.

a dialog structure, which permits the "producer" technicians and the "user" space managers to meet, to compare their points of view, and to express their desires and their constraints;

an experimental framework, which provides the opportunity to test various hypotheses advanced, in proportion to the progress of research;

an instance of planning, which will be able to proceed completely independently in an early stage, to the required arbitration between the needs of various users and the technical costs, which result in optimum solutions.



1. image 211-30 of 29 October 1972, channel 7 ($0.8\text{--}1.1\text{ }\mu\text{m}$, resolution $79\text{ m} \times 57\text{ m}$).
2. Flight at $7,000\text{ m}$ altitude, 1976 Tarascon mission, analog display of channel 6 ($0.60\text{--}0.65\text{ }\mu\text{m}$), resolution 17.5 m .
3. Flight at $1,500\text{ m}$ altitude, 1976 Tarascon mission, analog display of channel 10 ($0.9\text{ }\mu\text{m}\text{--}1.1\text{ }\mu\text{m}$), resolution 3.5 m .

This planning apprenticeship will bear fruit when future systems are put into operation, when permanent decisions are to be made which, while preserving the best interests of each, injure no one: spatial and spectral resolution, choice and range of observation zone, etc.

3.6 The Future of Remote Sensing in France

All the potentialities of remote sensing still are far from having been explored, and, both abroad and in France, research is being conducted.

Where is it?

At present, experiments have been conducted on a small number of locations and on limited subjects. The results often have been very interesting. Nevertheless, their precise nature does not permit generalization of their conclusions to the entire area.

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The experiments of PIORS have precisely the aim of filling in the empty spaces and, thus, of having a set of conclusions on which to base a reliability diagnosis.

How Does the Future Appear?

The technology is progressing:

the resolution of the Earth observation satellites is increasing, 20 m on the ground for the French Spot satellite in 1984 vs. 80 m for the Landsat satellites today;

in the 1980's, radar will permit reliable information to be obtained, whatever the meteorological conditions.

Due to this progress, the range of services contributed by remote sensing will increase considerably:

for example, let us take the case of crops, for which observation has to occur at a very precise time; the actual sensors can be obstructed by clouds; radar will permit the rendezvous to be made;

likewise, higher resolution will permit urban studies specialists or those responsible for coastal protection to have much more detailed information available.

In a more general manner, the actual methods of receiving information will have an appreciable complement in remote sensing, which will permit new information to be obtained, with simultaneous repetitive coverage of the most important ranges.

Users "participate" in this progress in two ways:

in information meetings of very specific nature organized by PIORS;

but, above all, in the project teams responsible for conducting an experiment until its completion.

They also are better placed, to carry out development of the tool towards its optimum use.

The success of such a program is a function of: the accuracy with which the needs of present and future French users are analyzed;

our capacity to find completely adapted technical solutions, in particular, from the point of view of cost, to problems which are raised.

Both are in the hands of the user. PIORS, by integrating the process of determination, perfection and putting into operation of the tool, provides them the opportunity to make their interests prevail.

4. PIORS AN ASSET FOR A NATIONAL REMOTE SENSING SYSTEM

4.1 A System Adapted to French Needs

Some major powers have made considerable advance in the field of remote sensing. This is the case in the USSR, Canada and, most especially, the USA. /22

In some measure, France is profiting from this technological advance. Thus, French organizations now use data received by the Landsat earth resources satellites, launched by NASA in 1972, 1975 and 1978.

However, the specific possibilities offered by foreign systems cannot always be transposed to French realities, in consideration of the major differences between the territories (extent, contours, climate, relief, etc.) and in the nature of user needs, which often are more exacting in our country of old tradition.

Finally, the specific nature of our problems and the services we can be called on to give other nations, especially the Arab and African countries, in the framework of our policy of cooperation, militates for an appropriate technology to be developed in France.

This, while making the best use of what has been acquired, will have some autonomy, with respect to that used abroad.

This autonomy will consist of:

- adaptation of the "resolution" of measurements to the characteristics of the problems which we have to solve;

- original processing procedures;

- possibility of permanent access to the parameters and data we need for the management of French space.

Without wishing to predetermine the nature of the remote sensing system which will satisfy these needs, it can be assumed that: /23

- the system will be based on satellites (especially French), which provide repetitive data at increased frequency (about each 15 days); these data will be used primarily for land management;

PRINCIPAL EARTH OBSERVATION SATELLITES¹

	Launch date	Resolution	Spectral bands	Frequency	Mission
Landsat 2	January 1975	79 x 57 m	0.5-0.6 μ m 0.6-0.7 0.7-0.8 0.8-1.1	18 days	Earth observation, land occupation and use, geology
Landsat C	March 1978	visible: 79 x 57 m IR: 240 m ²	same + thermal channel		same + soil moisture
Landsat D	1981	Vis-near IR: 30 m ² far IR: 120 m ²	6 channels from 0.5 to 12.6 μ m	16 days	same but better resolution
Spot	1984	20 m ² or 10 m ²	0.49-0.59 μ m 0.61-0.69 0.80-0.90 0.5-0.9 μ m	26 days	
HCMM	April 78	500 m ²	10.5-12.5 μ m 0.5-1.1 μ m	1.5 to 3.5 days	soil moisture, geothermal studies, thermal mapping of effluents, snowfields
Nimbus G	summer 78	800 m ²	4.7 μ m 8 11.2 other radio-meters radar	2-3 days	air pollution, oceanography, Earth radiation balance
Seasat	summer 78				oceanography
Meteosat	November 77	vis: 2.5 km ² IR: 5 km ²	0.5-1.1 μ m 5.7-7.1 10.5-12.2		geostationary meteorological satellite, 36,000 km, 1 image every half hour
Geos B and C	summer 78	same	same		same

¹ Landsat 1 has been put out of service. When a NASA satellite is in the planning stage, it is given a letter, which becomes a number when it is operational. Landsat C will become Landsat 3.

It is advisable to add to this table some Earth observation missions (metric camera, radar) of the space station (Spacelab) and of the NOAA TIROS series meteorological satellites.



1. City of Flint (Michigan): automatic classification of August 1975 Landsat view and cartography of main land use categories in an American urban sector.



2. City of Arles (Bouches-du-Rhone): IRC photograph, June 1975; note difference in urban organization between an old European city and its suburbs and the preceding American city.

some needs of a more fleeting nature and smaller spatial extent will be satisfied by airborne resources specially brought into use; they permit more precise complementary information to be obtained for more detailed studies.

Data collection, in particular, the data provided by satellites, can be centralized. On the other hand, at the level of the regions and certain departments, there can be the opportunity to establish common processing centers, to which all interested organizations will have access.

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4.2 The Perfection of Which Will Require that Certain Services be Brought Together

To perfect this autonomous French remote sensing satellite system in the 1980's, which will satisfy users and meet our policy objectives, some conditions must be met, in particular:

as complete as possible information on all potential users of remote sensing; this is being undertaken right now and should be accelerated in 1978;

formation of a base of users participating in experiments or proposing them; it aims at thorough study of scientific contributions and knowledge acquired "on the job"; also, PIORS is organizing work at organizations with equipment available, which permits the users themselves to process images of interest to them on interactive consoles, for example:

a more thoroughgoing dialog between producers and users; the best way to instigate it is to make the various categories of those involved in specific projects to work together during experiments undertaken by PIORS.

PIORS is the "motor" of the efficient, organized development of application of remote sensing techniques in France.

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